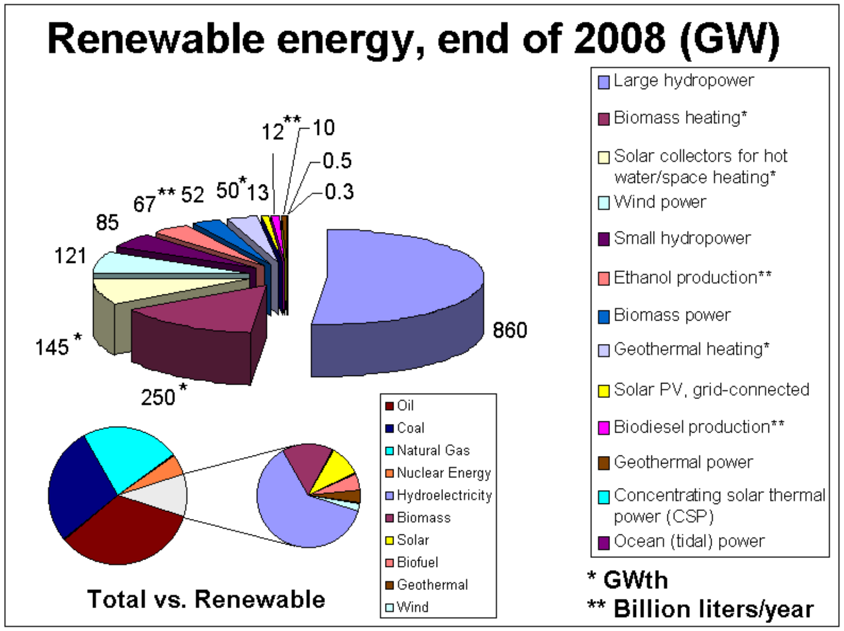
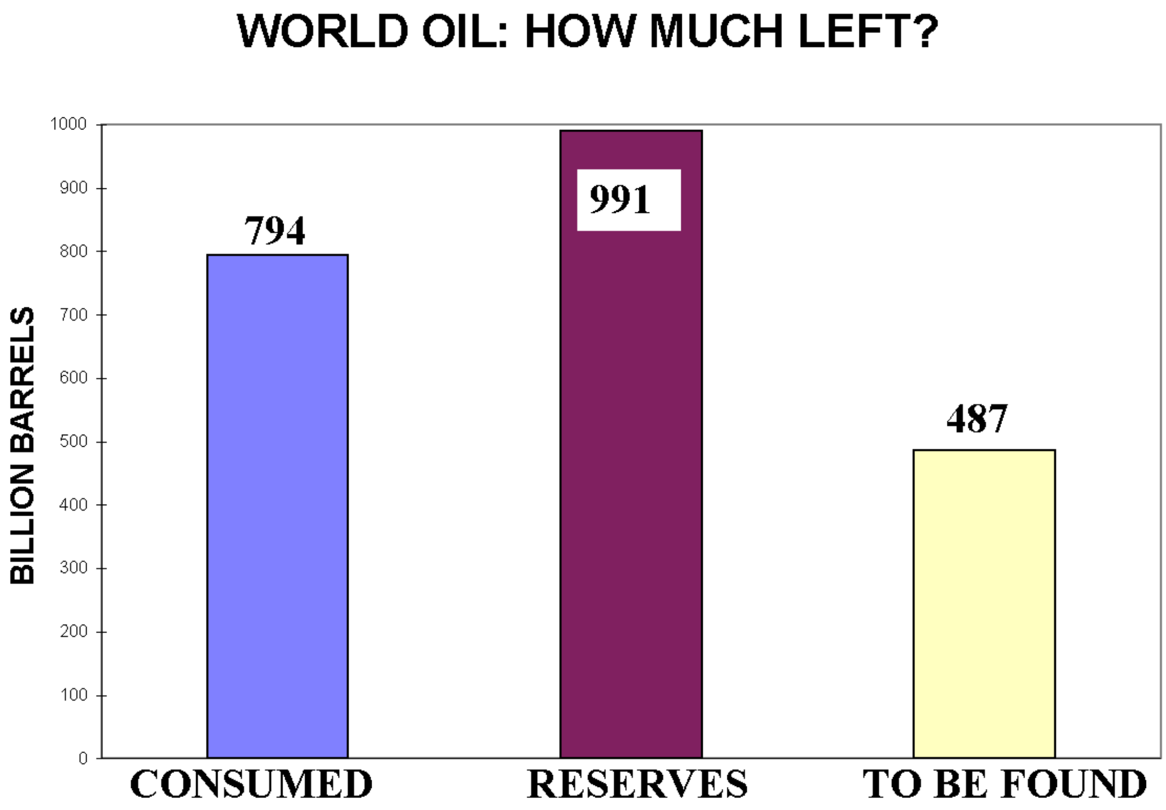
RENEWABLE RESOURCES

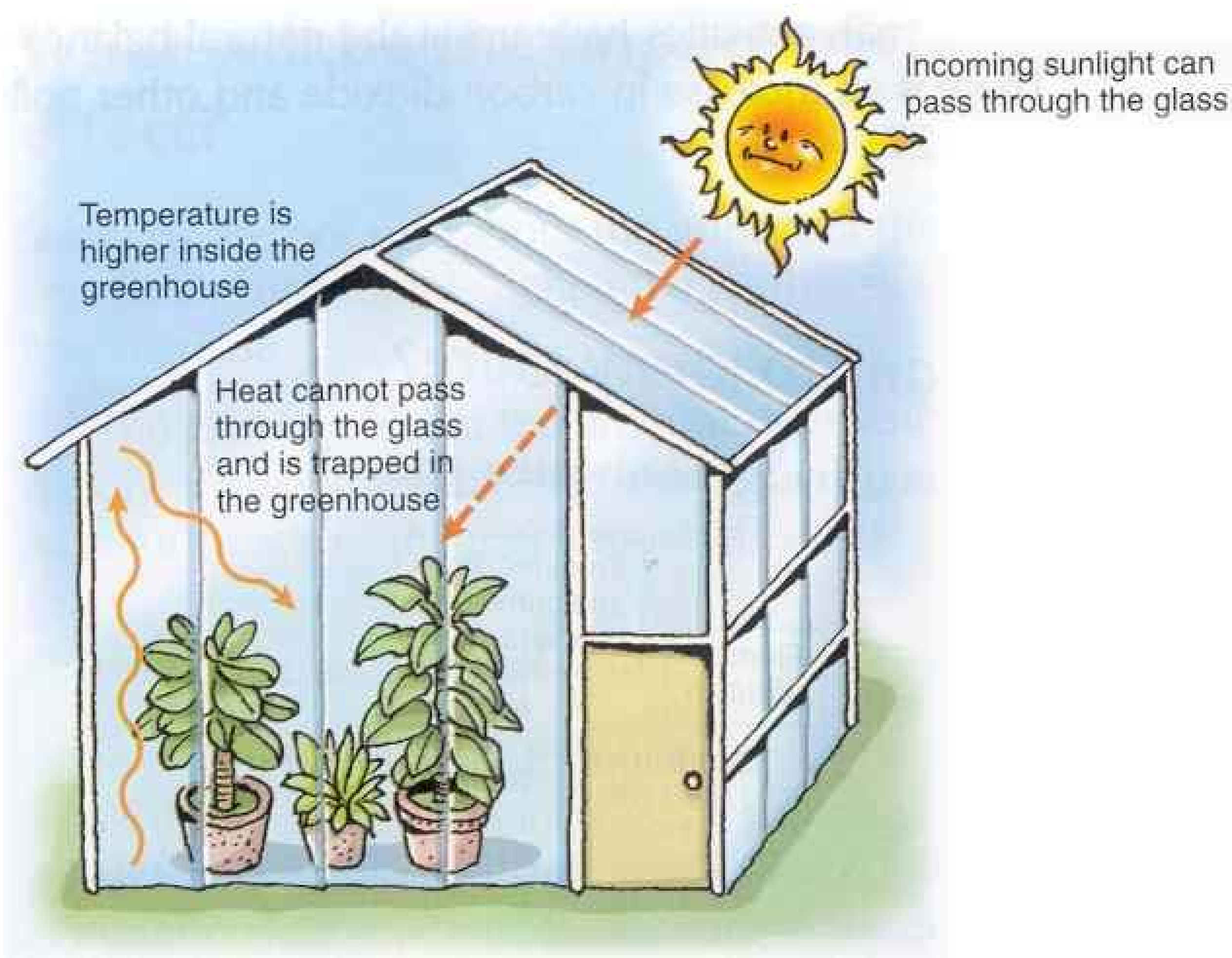
- Coal, oil, and natural gas are all fossil fuels created several millions of years
- they are being consumed much more rapidly than they are created. For that reason, fossil fuels are considered as non-renewable; that is, they are not replaced as soon as we use them.
- leads to pollution and many environmental impacts

- Renewable energy are energy that will last Moreover these renewable energy sources are much more environmentally friendly than fossil fuels when they are burned.




WORLD OIL: HOW MUCH LEFT?
BILLION BARRELS
1000
900
800
700
600
500
400
300
200
100
0
794
991
487
CONSUMED
RESERVES
TO BE FOUND

Greenhouse Effect



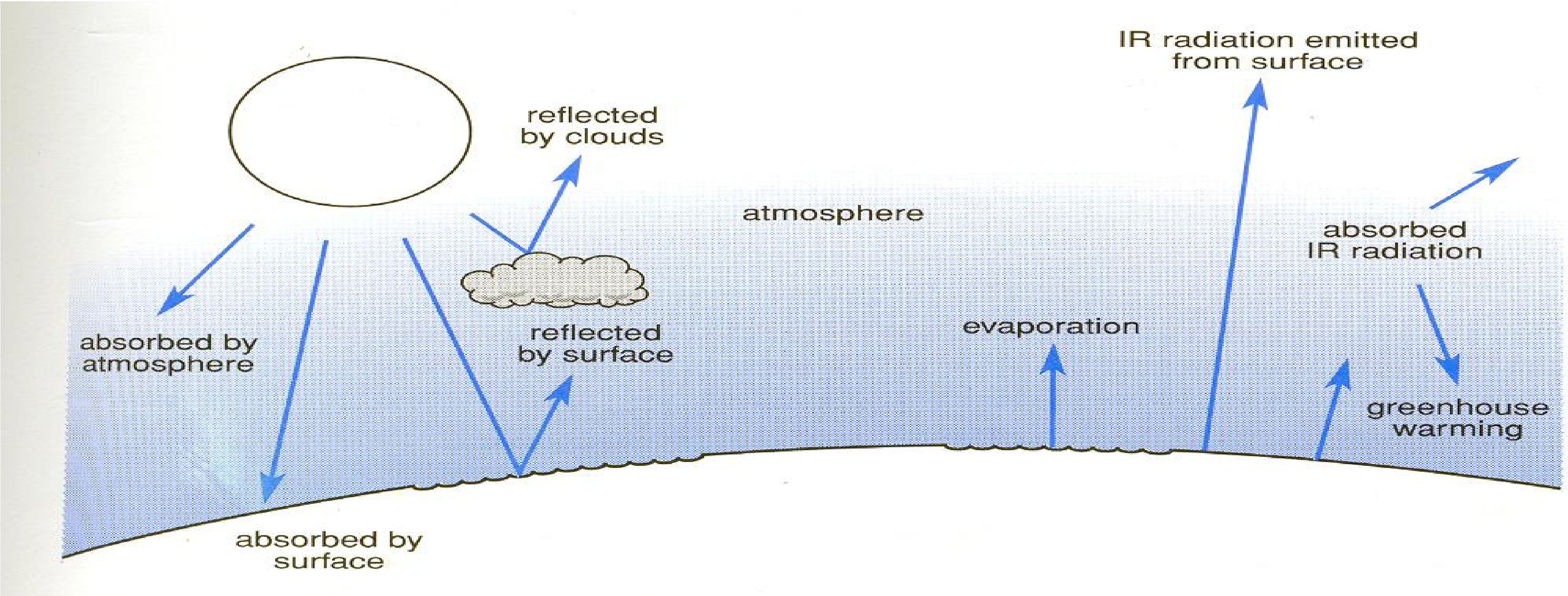
- If the Earth has no atmosphere, its average surface temperature would be very low of about -18^{o}C rather than the comfortable 15^{0}C found today.

- The difference in temperature is due to a suite of gases called greenhouse gases which affect the overall energy balance of the Earth's system by absorbing infra-red radiation.

- The two main gases (N_2 and O_2) are effectively transparent to terrestrial radiation, i.e. they are very poor emitters of the terrestrial radiation.

- However the minor components, CO_2 and H_2O vapour, CH_4, NO_2, CO, O_3 and chlorofluorocarbons [CFCs] absorb the terrestrial radiation strongly
- the Earth-atmosphere system balances absorption of solar radiation by emission of infra-red radiation to space.
- Due to greenhouse gases, the atmosphere absorbs more infra-red energy than it re-radiates to space, resulting in a net warming of the Earth-atmosphere system and of surface temperature. this is the “natural greenhouse effect”.
- With more infra-red radiation will be trapped in the Earth’s surface which contribute to the “enhanced greenhouse effect”

- an increase in CO_2 level of atmosphere could prevent sufficient energy loss, but it could cause a disastrously increase in Earth's temperature



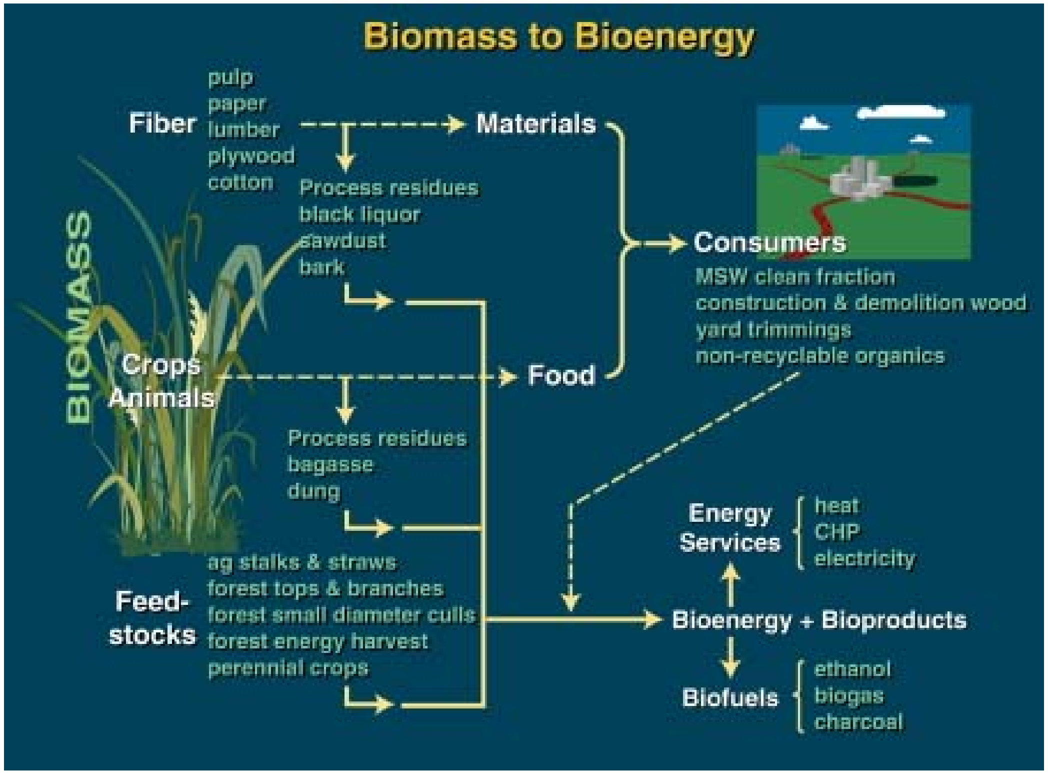
RENEWABLE ENERGY SOURCES

- Renewable energy systems use resources that are constantly replaced and are usually less polluting

- Renewable resources are well-recognized as a good way to protect the economy against price fluctuations and against future environmental costs.

Biomass as Renewable Resource

- Biomass as the solar energy stored in chemical form in plant and animal materials is among the most precious and versatile多方面適用resources on earth

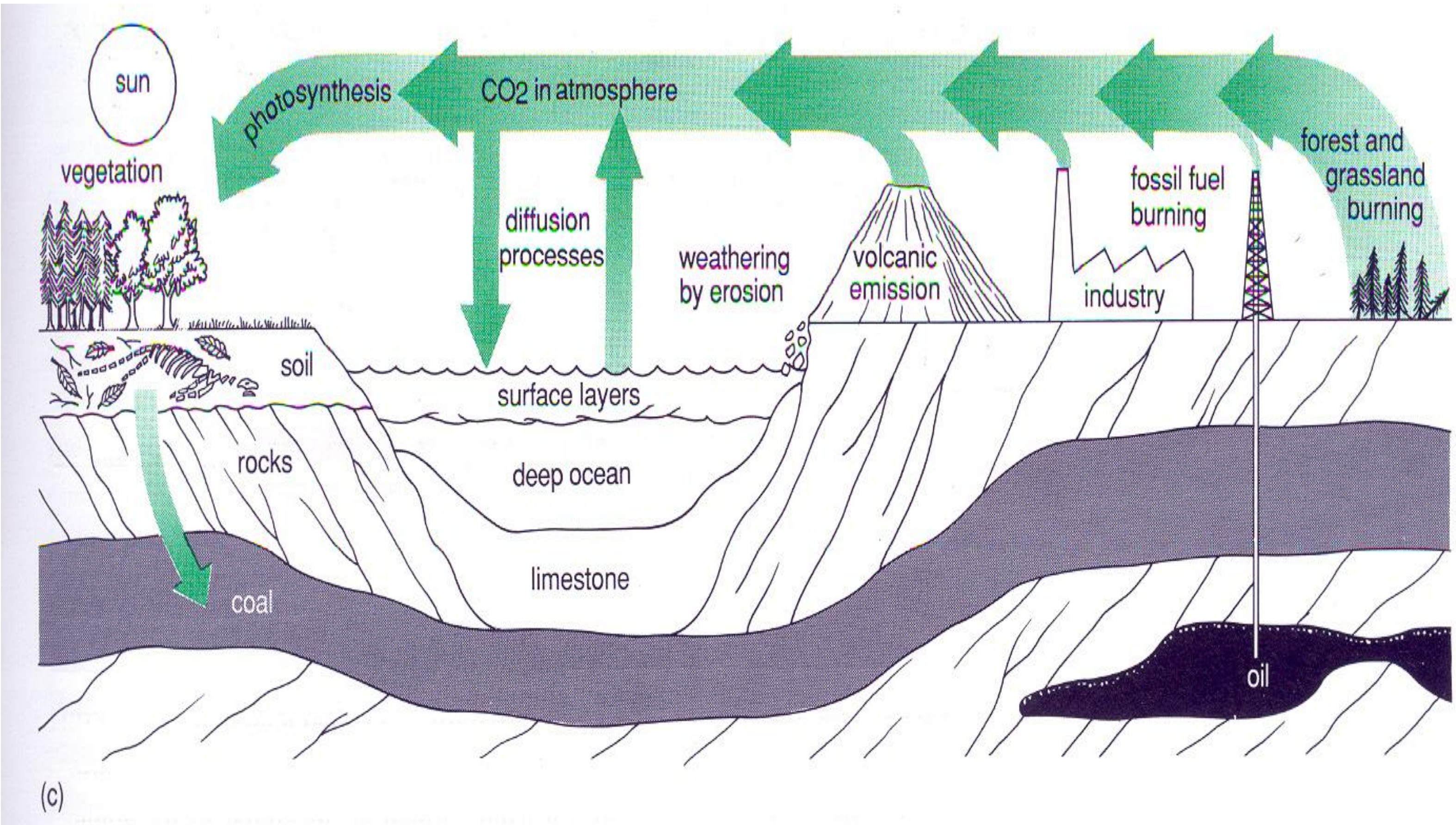


THE CHEMICAL COMPOSITION OF BIOMASS

- The chemical composition of biomass varies among species, but plants consist of about 25% lignin and 75% carbohydrates or sugars.

- Nature uses the long cellulose polymers to build the fibers that give a plant its strength. The lignin fraction acts like a “glue” that holds the cellulose fibers together.

- Carbon dioxide from the atmosphere and water from the earth are combined in the photosynthetic process to produce carbohydrates (sugars) that form the building blocks of biomass.


sun
photosynthesis
CO2 in atmosphere
vegetation
diffusion processes
weathering by erosion
volcanic emission
fossil fuel burning
forest and grassland burning
industry
soil
surface layers
rocks
deep ocean
limestone
coal
oil
(c)

- . It already supplies 4 % of the world’s primary energy consumption.
- On average, biomass produces 38 % of the primary energy in developing countries. Biomass is likely to remain an important global source in developing countries well into the next century.

FOOD OR FUEL?

- A major criticism often levelled against biomass, particularly against large-scale fuel production, is that it could divert agricultural production away from food crops, especially in developing countries.

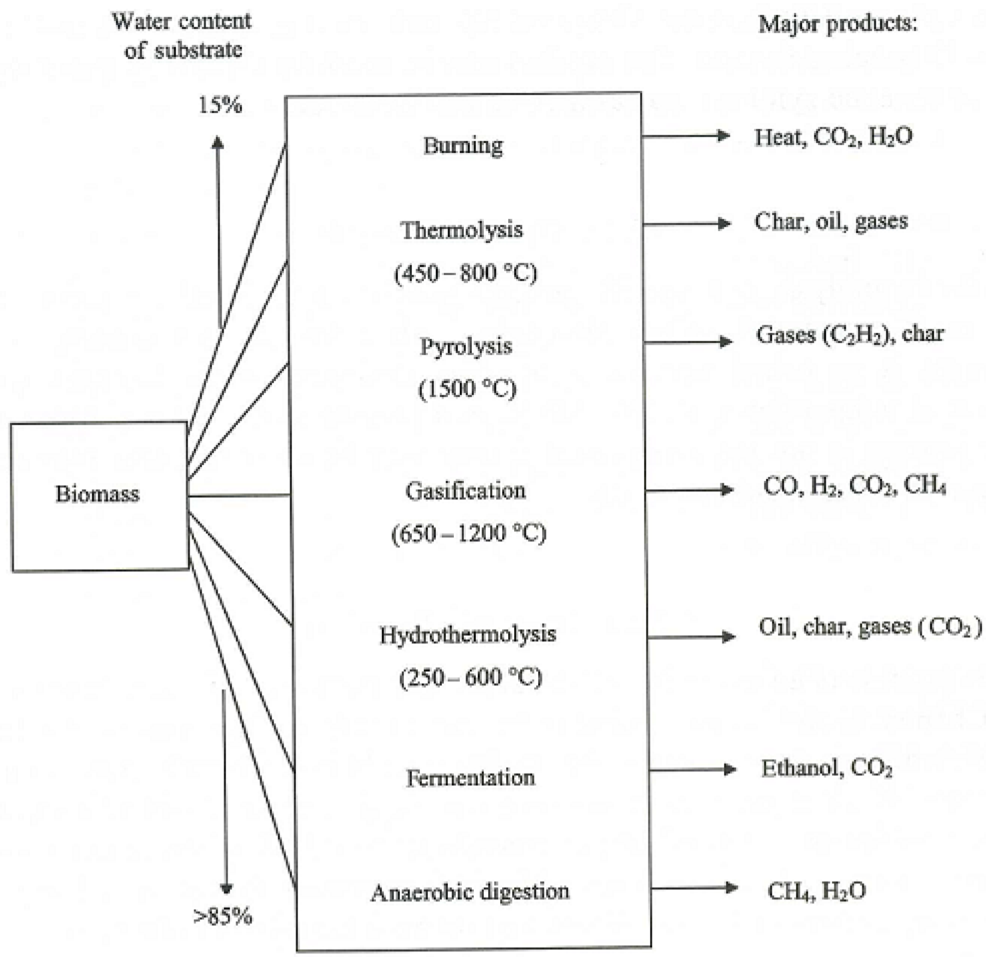
- The argument should be analysed
  - world's (or an individual country's or region's) real food situation of food supply and demand
  - the under-utilized agricultural production potential,
  - the increased potential for agricultural productivity, and
  - the advantages and disadvantages of producing biofuels

- The ash content of biomass is much lower than for coals, and the ash is generally free of the toxic metals and other contaminants and can be used as soil fertiliser.
- Biomass energy can be used to generate heat and electricity through direct combustion in modern devices,
  - ranging from very-small-scale domestic boilers to multi-megawatt size power plants electricity (e.g. via gas turbines), or
  - liquid fuels for motor vehicles such as ethanol, or other alcohol fuels.

FUEL	Content of water %	MJ/kg	kW/kg
Oak- tree	20	14,1	3,9
Pine-tree	20	13,8	3,8
Straw	15	14,3	3,9
Grain	15	14,2	3,9
Hard coal	4	30,0-35,0	8,3
Brown coal	20	10,0-20,0	5,5
Heating oil	-	42,7	11,9
Bio methanol	-	19,5	5,4

METHODS OF GENERATING ENERGY FROM BIOMASS

- Direct combustion of biomass.
- Thermochemical processing to upgrade the biofuel. Processes in this category include pyrolysis, gasification and hydrothemolysis.
- Biological processing. Natural processes such as anaerobic digestion and fermentation which lead to a useful gaseous or liquid fuel.



Water content of substrate
15%
>85%
Biomass
Burning
Thermolysis
(450 – 800 °C)
Pyrolysis
(1500 °C)
Gasification
(650 – 1200 °C)
Hydrothermolysis
(250 – 600 °C)
Fermentation
Anaerobic digestion
Major products:
Heat, CO_2, H_2O
Char, oil, gases
Gases (C_2H_2), char
CO, H_2, CO_2, CH_4
Oil, char, gases (CO_2)
Ethanol, CO_2
CH_4, H_2O

BURNING (COMBUSTION)

- One problem with this method is its very low efficiency. With an open fire most of the heat is wasted and is not used to cook or whatever.

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Combustion of wood can be divided into four phases:

- Water inside the wood boils off. Even wood that has been dried for ages has as much as 15 to 20% of water in its cell structure.
- Gas content is freed from the wood. It is vital that these gases should burn and not just disappear up the chimney.
- The gases emitted mix with atmospheric air and burn at a high temperature.
- The rest of the wood (mostly carbon) burns. In perfect combustion the entire energy is utilised and all that is left is a little pile of ashes.

Three things are needed for effective burning

- :
- high enough temperatures;
- enough air, and
- enough time for full combustion.

- The energy content of a cubic metre dry wood is 10 GJ, which is ten million kJ.
- To raise the temperature of a litre of water by 1 degree Celsius requires 4,2 kJ of heat energy
  - which is equivalent to 40 cubic centimetres of wood - one small stick

Thermolysis and Pyrolysis

- These both involve heating biomass (mainly wood), largely in the absence of oxygen, at temperatures from a few hundred degrees centigrade (thermolysis) up to 1500oC (pyrolysis).

- At the lower temperature char or charcoal is a major product, and this has become a valuable export commodity for many wood-rich countries.

- The other main product is a fuel oil, but this is usually quite acidic, requiring treatment before it can be used.

- Overall thermolysis is relatively inefficient, with well over 50 % of the energy content of the original biomass being lost.

- At higher temperatures the char content is considerably reduced, the main product being a gas mixture rich in H_2, CO and acetylene, the composition varying with temperature

GASIFICATION氣化

- Electricity from biomass is produced via the condensing steam turbine, in which the biomass is burned in a boiler to produce steam’ which is expanded through a turbine driving a generator.

- The technology is well-established, robust and can accept a wide variety of feedstocks.

- However, it has a relatively high unit-capital cost and low operating efficiency with little prospect of improving either significantly in the future. There is also the inherent danger in steam

- gasification captures about 65-70% of the energy in solid fuel by converting it first into combustible gases.

Biomass gasification systems generally have four principal components:

- (a) Fuel preparation, handling and feed system;
- (b) Gasification reactor vessel;
- (c) Gas cleaning, cooling and mixing system;
- (d) Energy conversion system

Hydrothermolysis

- Producing an oil-like material, called bio-crude, with a low oxygen content. It involves the treatment of the biomass with water at temperatures of 200 – 300oC and pressures over 30 bar.

Anaerobic Digestion

- anaerobic treatment of waste, and is also similar to the natural process operating in landfill sites, which evolves methane.
- By treatment of biomass with bacteria in the absence of air a gas rich in methane is produced;
- a typical digester may produce over 300m3 of gas containing over 50 % methane per tone of dry biomass.

Bioethanol

- Production of ethanol by fermentation of glucose-based crops such as sugar cane and corn starch using Saccharomyces yeasts,
- because of its relatively high water content, cannot be mixed with gasoline and must be used as a single fuel in specially adapted engines.
- the preferred product is anhydrous ethanol which can be mixed with gasoline at levels up to 22% and used in conventional engines

Issue

- I. In the production process an acidic by-product, called vianesse, largely consisting of organic and amino acids, is produced at a level of over ten times the amount of ethanol produced. This material has a high COD and BOD, and poses significant problems

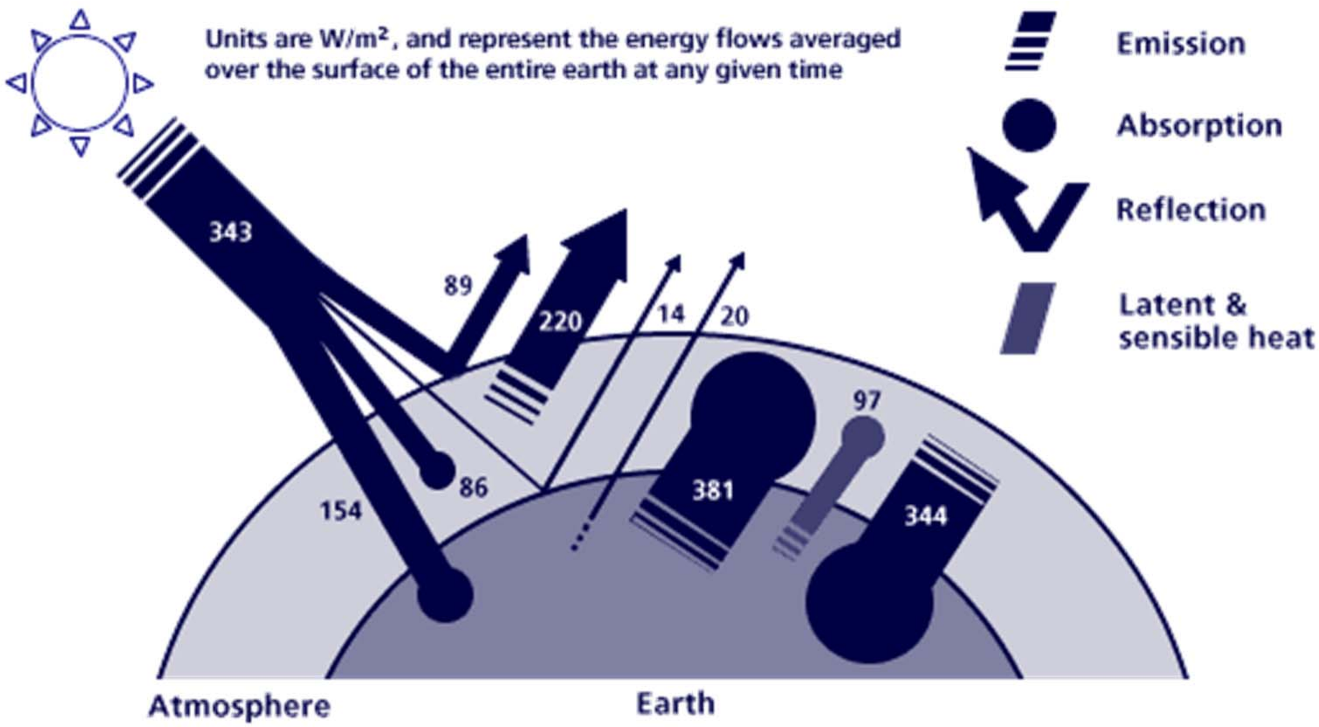
- II. Traditional fermentation processes can only make use of glucose, leaving other sugars present, notably xylose, untouched. This both increases the 'waste' element and lowers the competitiveness of the process.

- III. Fermentation processes typically produce a product with an ethanol concentration of between 7% and 15%. Above this level the yeasts find it difficult to perform. The usual method of concentration is by distillation, which is a very expensive and energy-intensive.

Solar Power

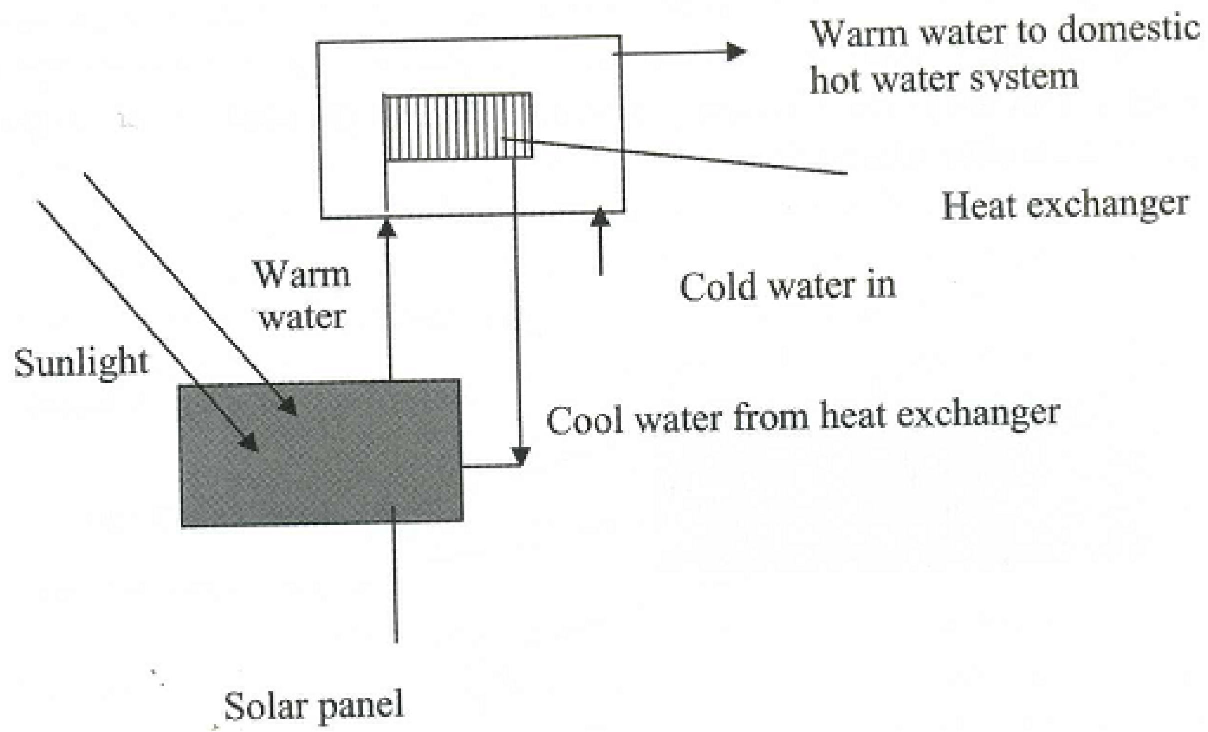
- The sun generates an enormous amount of energy - **approximately 1.1 x 10 E^{20} kilowatt-hours every second.** (A kilowatt-hour is the amount of energy needed to power a 100 watt light bulb for ten hours.)

- Because of reflection, scattering, and absorption by gases and aerosols in the atmosphere, however, only 47% of this, or approximately 700 quadrillion (7 x 10 E^{17}) kilowatt-hours, reaches the surface of the earth.


Units are W/m², and represent the energy flows averaged over the surface of the entire earth at any given time
Emission
Absorption
Reflection
Latent & sensible heat
343
89
220
14
20
97
86
154
381
344
Atmosphere
Earth

Two main methods for harnessing the sun's energy

- **Use sunlight as a source of heat to warm up water, usually termed solar heating.**
- **Solar panels or collectors often consist of a series of fine copper water-carrying tubes encased in glass.**
- As the sun heats the water in the tubes a siphon system is set up which causes the hot water to rise into a heat exchanger and be replaced by colder water.

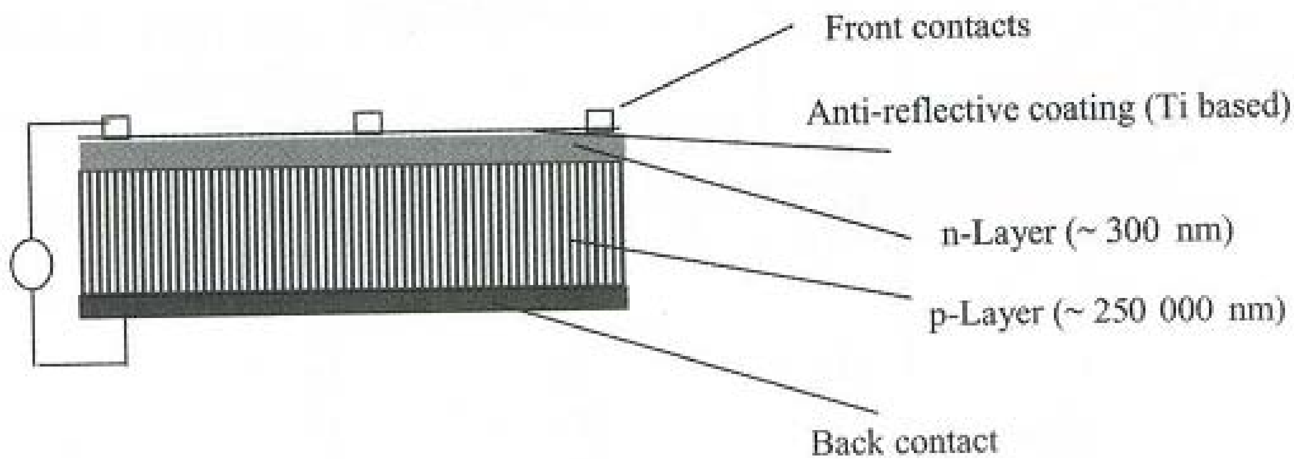

Warm water to domestic hot water system
Heat exchanger
Cold water in
Warm water
Sunlight
Cool water from heat exchanger
Solar panel

- **Photovoltaic cells (PV) capable of directly converting sunlight into electricity are made of semi-conducting materials**

- **By doping the silicon crystal with a small amount of phosphorus, an n-type semiconductor is formed,** which act as the negative side of the solar cell. Conversely **p-type semiconductor can be made by doping silicon with boron.**

- **By joining two semiconductors together a junction is set which enable electrons to move to fill the holes.** Which light hit the p-n junction it gives electrons enough energy to escape the valence band and **leaves them free to move around the material conducting electricity**.

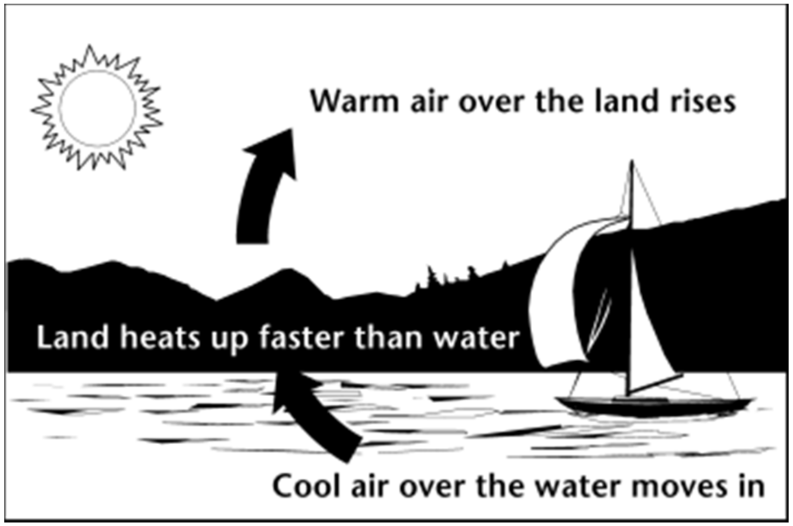
- **A top anti-reflective coating helps reduce reflectance and improve efficiency.**


Front contacts
Anti-reflective coating (Ti based)
n-Layer (~ 300 nm)
p-Layer (~ 250 000 nm)
Back contact

Wind energy

- a form of solar energy produced by uneven heating of the Earth's surface.

- **About 1 to 2 per cent of the energy coming from the sun is converted into wind energy.**



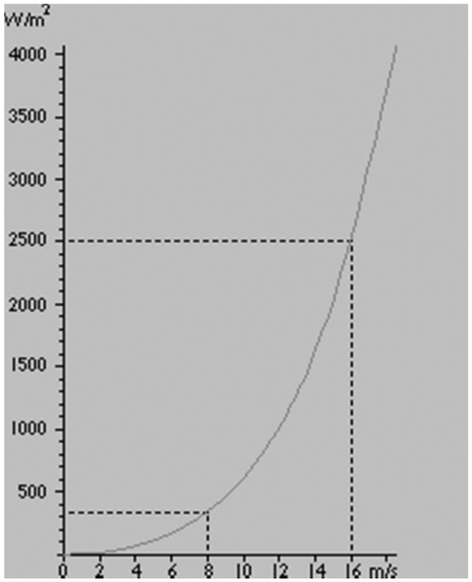
- It produces no health-damaging air pollution, forest-destroying acid rain, climate-destabilising carbon emissions, or dangerous radioactive waste.

- Wind energy follows seasonal patterns that provide the best performance in the winter months and the lowest performance in the summer months.

- the amount of wind power generated is proportional to the density of air, area swept by the rotor blades of the wind turbine, and to the cube of the wind speed.

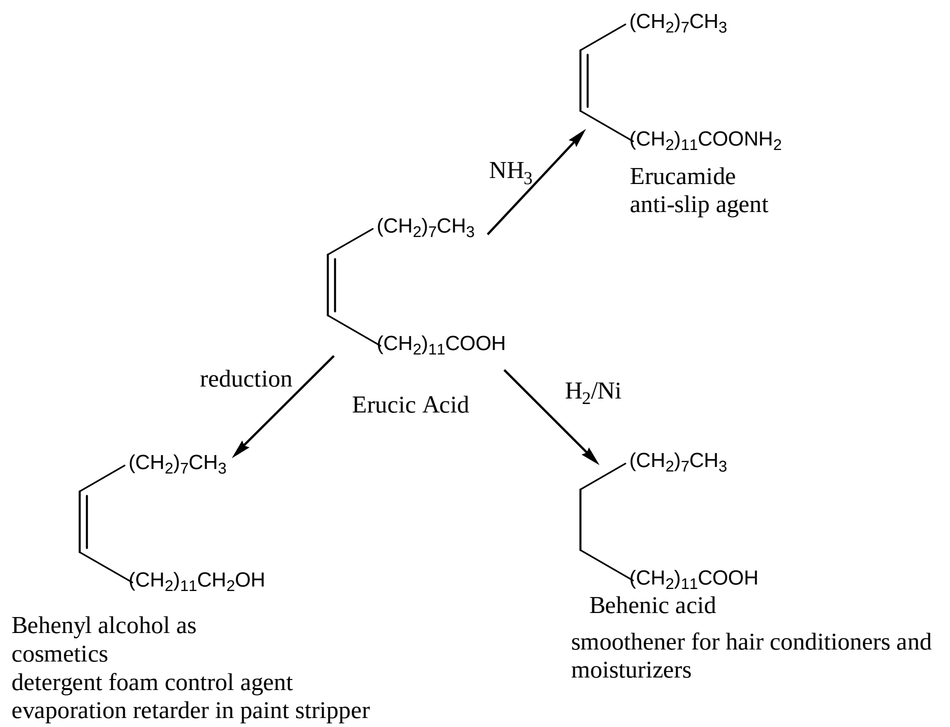
- The more air can move the blades, the faster the blades will rotate, and the more electricity the wind generator will produce.
- Air is more dense in winter than in the summer. Therefore, a wind generator will produce more power in winter than in summer at the same wind speed.
- The rotor area determines how much energy a wind turbine is able to use from the wind. Since the rotor area increases with the square of the rotor diameter, a turbine which is twice as large will receive four times as much as energy.

- Increasing wind velocity increases the amount of air mass passing the rotor, so increasing wind speed will also have an effect on the power output of the wind system.
- The formula for the power in Watts per $m^2 = 0.5 \times 1.225 \times v^3$, where v is the wind speed in m/s.



Fatty acids

- One of the examples is erucic acid. The main commercial source of erucic acid is a specially bred form of rapeseed 油菜籽.



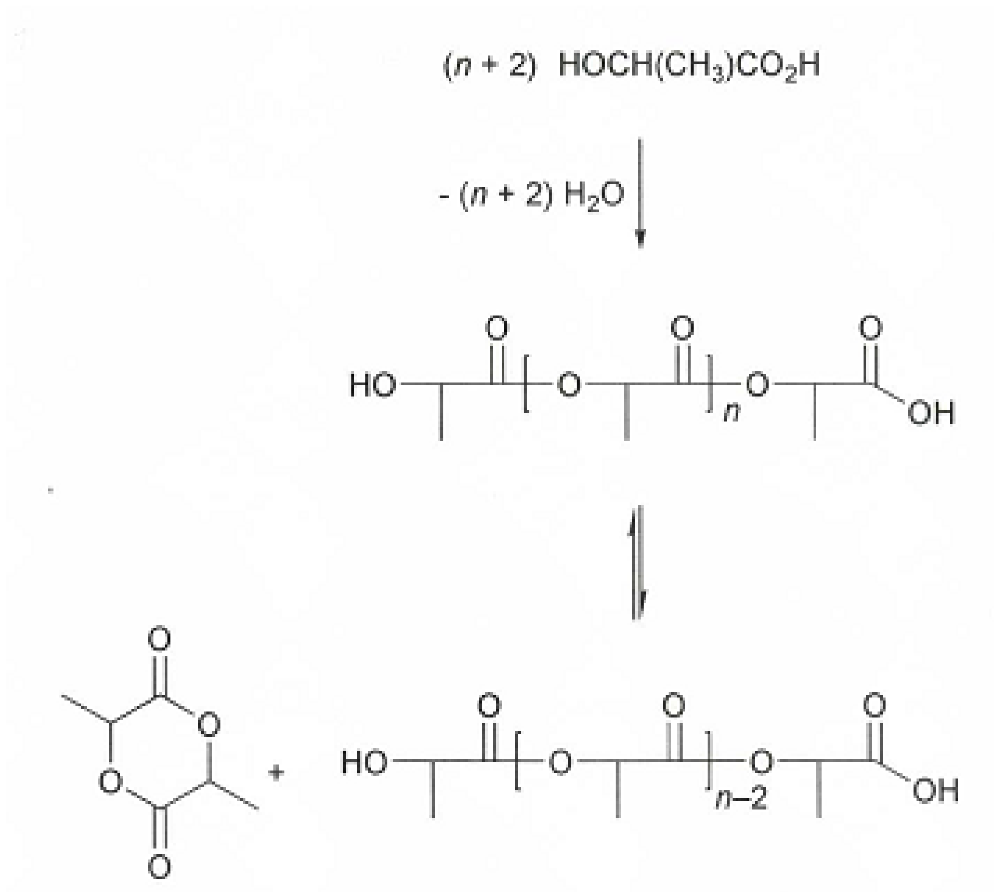
Fatty acids as lubricants

- By lowering the coefficient of friction between moving parts, thereby allowing surfaces to slide over one another more easily and hence preventing wear and increasing components lifetime,

- Increasing levels of di- and tri-unsaturation reduce the oxidative and thermal stability of the oils whilst high levels of unsaturated acids raise the pour point.

Polymers from Renewable Resources

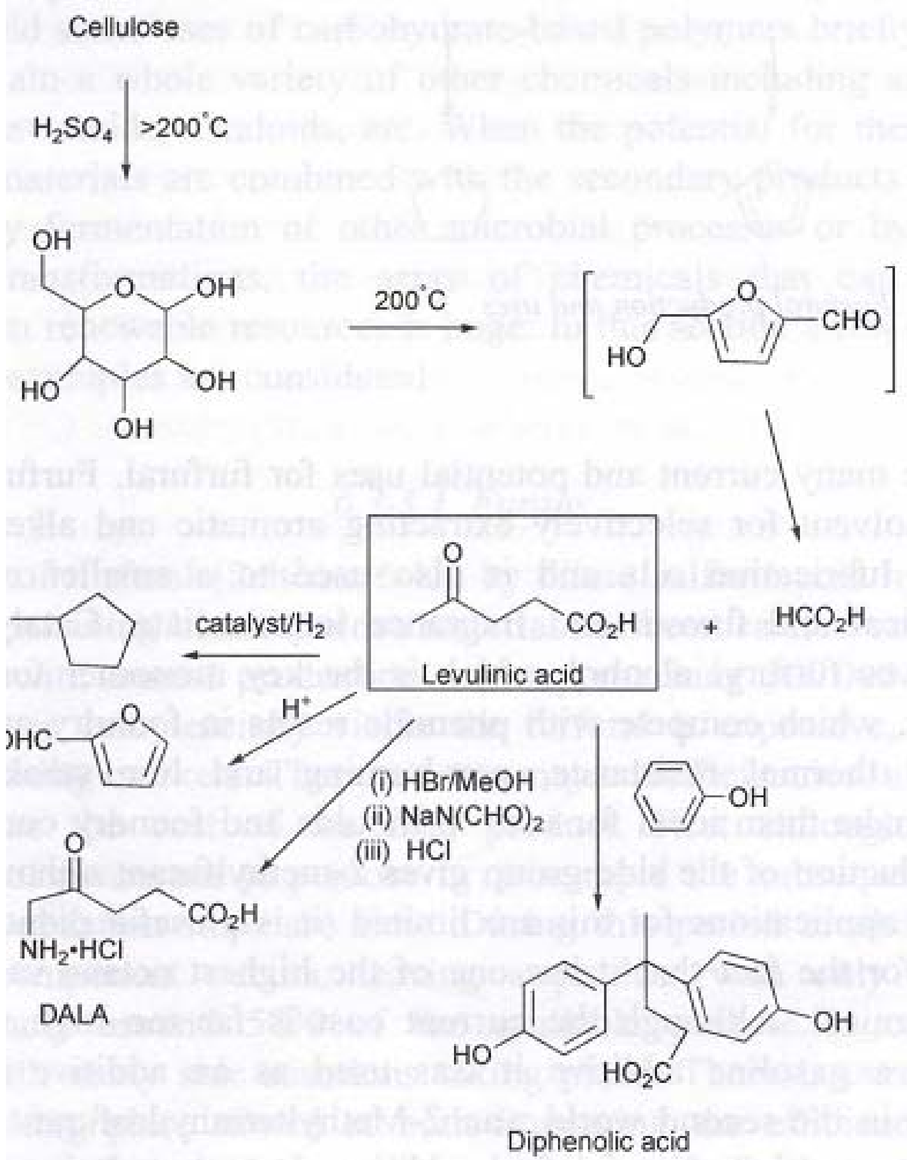
- **polylactic acid (PLA) which has been produced for many years as a high-value material use in medical applications such as dissolvable stitches and controlled release devices, because of the high production costs.**
- **a competing depolymerization take place to produce cyclic lactide.** As the degree of polymerization increases the rate slows down until the rates of depolymerization and polymerization are the same.


(n + 2) HOCH(CH3)CO2H
- (n + 2) H2O
HO
O
OH
n
n–2
+

- **The solution to this problem has been to isolate the lactide and to polymerize this directly using a tin(II) 20-(ethyl)hexanoate catalyst at temperatures between 140 and 160^{o}C.**

Levulinic acid from Cellulose

- sometimes referred to as a platform chemical
- produced by high-temperature acid hydrolysis of cellulose to glucose followed by a further controlled high temperature ring-opening dehydration step.
- Yields are low owing to the formation of tars.
- Preventing tar from building up can done by removing the product from the acidic medium as soon as it is formed.


Cellulose
H_2SO_4
>200°C
200°C
OH
HO
CHO
HCO_2H
+
O
CO_2H
Levulinic acid
catalyst/H_2
H^+
OHC
(i) HBr/MeOH
(ii) $NaN(CHO)_2$
(iii) HCl
NH_2•HCl
DALA
HO_2C
Diphenolic acid

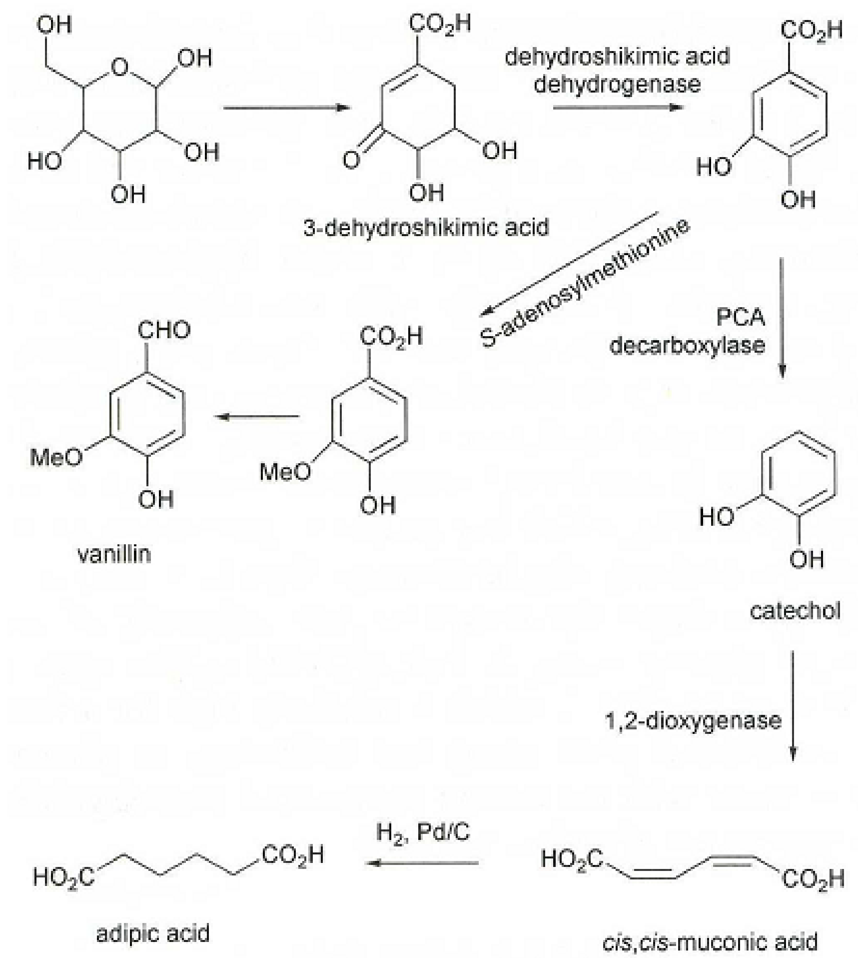
Adipic acid from glucose

- Traditioanlly adipic acid is produced by benzene involving hydrogenation to cyclohexane followed by an inefficient oxidation step to give a mixture of cyclohexanol and cyclohexanone.

- One of the problems with this process is the production of nitrous oxide, a potent greenhouse gas.

-

- Alternatively adipic acid may be produced by simple catalytic hydrogenation of cis, cis-muconic acid which can be directly synthesized from glucose using genetically modified E.coli.


OH
O
OH
HO
OH
OH
CO2H
O
OH
OH
3-dehydroshikimic acid
dehydroshikimic acid
dehydrogenase
CO2H
HO
OH
S-adenosylmethionine
PCA
decarboxylase
CHO
MeO
OH
vanillin
CO2H
MeO
OH
HO
OH
catechol
1,2-dioxygenase
H2, Pd/C
HO2C
CO2H
adipic acid
HO2C
CO2H
cis,cis-muconic acid